University of Diyala
College of Engineering
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# Air Conditioning

## 7-CONDITIONS FOR COMFORT

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## Conditions for Comfort

**Design Standard** deals with indoor thermal comfort in normal living environments and office-type environments. It does not deal with occupancy periods of less than 15 minutes.

The Standard recognizes that individual perceptions of comfort can be significantly modified by prior exposure. For example, consider people coming into a building that is air-conditioned to 28 C on a very hot day, when it is 40 C outside. The building is obviously cooler as they enter it. After they have been in the building for half an hour, they will have adjusted and will probably consider the building excessively warm.

When considering issues of comfort, the Standard addresses two situations:

1. **Buildings with occupant-operable windows**
2. **Buildings with mechanically conditioned spaces**.

1. **Buildings with occupant-operable windows**

People behave differently when they have windows they can control. They have different, less demanding, expectations due to their knowledge of the external environment and their control over the windows. They will also choose how they dress, knowing that the building temperatures will be significantly influenced by external temperatures.

Figure, shows the **acceptable range** of "indoor operative temperatures" plotted against "mean monthly air temperature" for

Activity levels of 1.0 to 1.3 met

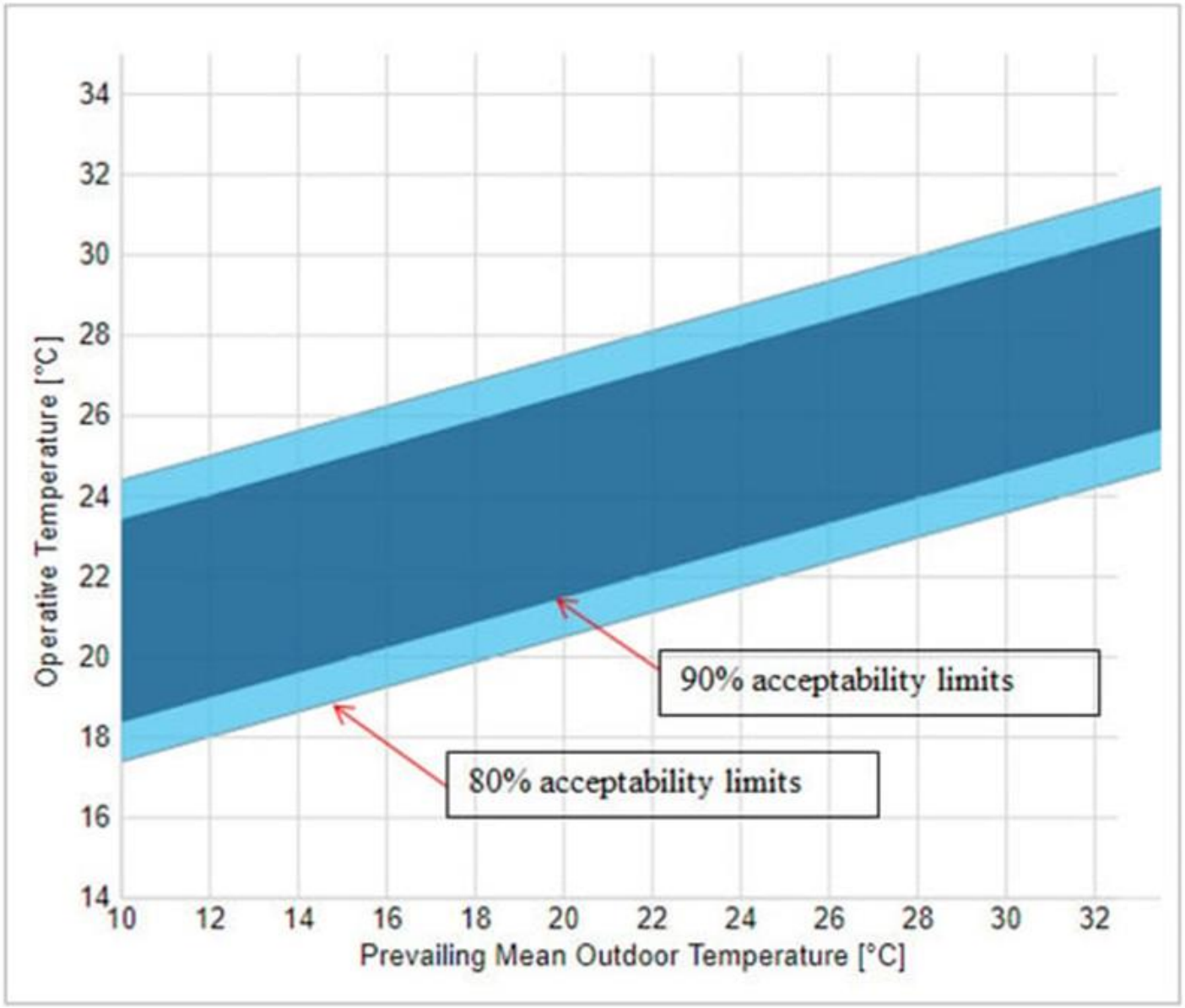
Person not in direct sunlight

Air velocity below 0.2 m/s

No specific clothing ensemble values

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This acceptable range is called the **comfort envelope**. The **indoor operative temperature** is the average of the air temperature and radiant temperature.

The **mean monthly outdoor temperature** is the average of the hourly temperatures; data is normally available from government environmental-monitoring departments.

The chart only goes down to a mean monthly temperature of 10 C, indicating that operant-controlled windows (opening windows) do not provide acceptable thermal comfort conditions in cooler climates during the winter.

The plot shows the range of comfortable operative temperatures for 80% acceptability, the normal situation, and a narrower comfort band that will provide a higher standard of comfort, 90% acceptability. For example, for a location with a maximum summer mean-monthly temperature of 20 C, the range for 80% acceptability is between 20.5 C and 27.5 C.

**Note** that the normal situation suggests that 20% of the occupants, or 1 in 5, will not find the thermal conditions acceptable!

2. **Buildings with mechanically conditioned spaces**.

Mechanically conditioned spaces are arranged into three classes:

**Class A – high comfort**

**Class B – normal comfort**

**Class C – relaxed standard of comfort**

Standard 55 includes comfort charts for Class B spaces only. To calculate comfort conditions for Classes A and C, the designer uses a BASIC computer program.

The Class B thermal limits are based on 80% acceptability, leaving about 10% of the occupants not comfortable due to the overall thermal conditions and 10% not comfortable due to local thermal discomfort.

**Class B Comfort Criteria**

The Standard provides a psychrometric chart, showing acceptable conditions for a Class B space for:

Activity between 1.0 and 1.3 met

Clothing 0.5 to 1.0 clo

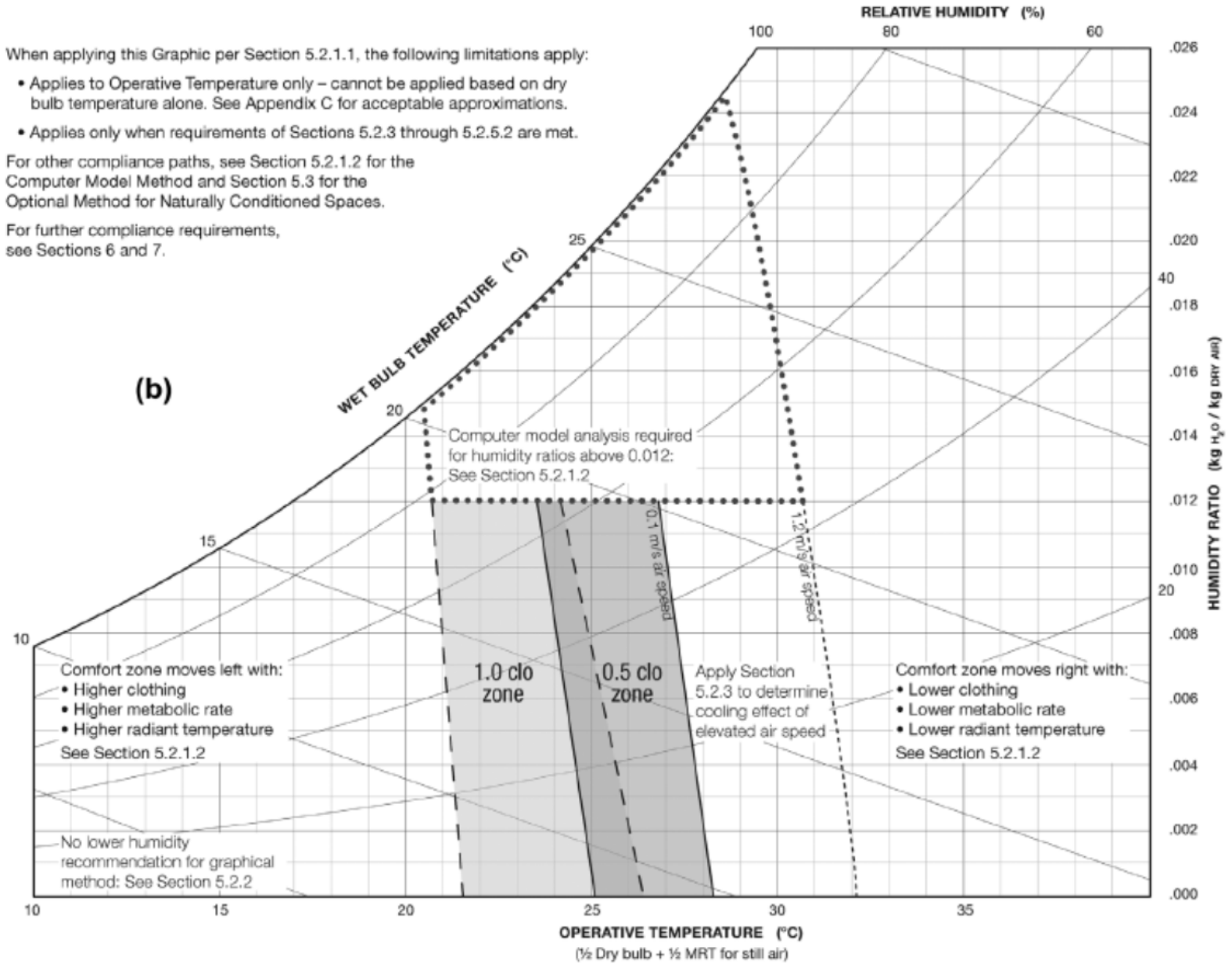
The air speed is to be below 0.2 m/s

The person must not be in direct sunlight

For spaces where it is reasonable to assume that clothing will be around 0.5 clo in the summer, and a design humidity of between 40% and 50%, the acceptable conditions, the comfort envelope, will be within the heavy lines on the chart.

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**Human and Environment**



Remember that the chart is for 80% acceptability, although ideally 100% of the occupants would find the conditions thermally acceptable. The occupants do have some limited flexibility with clothing in most situations.

**Example 1:** Let us suppose we wish to minimize the size of the air-conditioning plant; then we could choose design conditions of 27 C at 50% relative humidity (**rh**), and 28 C at 40% rh. It must be recognized that when the designer designs on the limit, it means that more people are likely to be uncomfortable than if the designer chooses to design for the center of the comfort temperature band.

**Example 2:** Let us consider a different situation, a prestige office building with, at the design stage, unknown tenants. Here we should allow for both light dress and full suits, the full range 0.5 to 1.0 clo. If the design relative humidity is to be 50%, then we should select the area of overlap and choose 24.5 C as our design temperature.

**Example 3:** As a third example let us consider a desert town with an outside design-condition of 35 C and 20% relative humidity. If we pass the incoming air over a suitably sized evaporative cooler, the air will be cooled and humidified to 25 C and 40% which is nicely within the comfort zone for people with 0.5 clo. In this case, we can achieve acceptable thermal comfort for supply ventilation using an evaporative cooler.

**Indoor design conditions:**

| Season | Dry-Bulb Temp (°C) | RH (%) | Air Velocity (m/s) |
|---|---|---|---|
| Summer | 23–26 | 40–60 | ≤ 0.25 |
| Winter | 21–24 | 30–50 | ≤ 0.20 |

**Indoor Air Quality (IAQ):**

The maintenance of indoor air quality (IAQ) is one of the major objectives of air-conditioning systems because IAQ problems are a significant threat to health and productivity.

The primary factors that influence and degrade IAQ are **particles, gases, and vapors** in the air.

Ways of maintaining good IAQ by:

- Controlling the source of pollutants within the space.
- Using filters to prevent pollutants and contaminants from entering the space.
- Diluting the pollutants and contaminants within the space.

**Outdoor design conditions:**

Outdoor design conditions represent the climatic extremes used to size HVAC equipment (cooling and heating systems). The outdoor design conditions are listed in table **4-7.**

**Ventilation:**

Ventilation is the process of supplying or removing air by natural or mechanical means to maintain acceptable indoor air quality and comfort conditions.

**Objectives of Ventilation**

- Provide Fresh Air to dilute indoor contaminants.
- Control Temperature & Humidity.
- Remove Heat and Moisture from occupants and equipment.
- Maintain Positive or Negative Pressure (as needed).
- Enhance Comfort and Health.

## Types of Ventilation Systems

### A. Natural Ventilation

Relies on wind pressure and temperature differences.

**Advantages:** Energy-saving, Simple and low-cost

**Disadvantages:** Poor control over airflow, Weather dependent

**Applications:** Residential buildings, Low-rise structures with windows or ventilators

### B. Mechanical Ventilation

Air is moved using fans and ducts.

**Supply system:** brings in filtered outdoor air.

**Exhaust system:** removes indoor air.

**Balanced system:** equal supply and exhaust for control and energy recovery.

**Advantages:** Controlled air quantity and direction, Effective for large or sealed buildings

**Disadvantages:** Requires electrical energy, Maintenance and noise

**Fresh Air Requirements**

ASHRAE Standard 62.1 provides recommended outdoor air supply rates as listed in **table 4.5**. These values comes from the long experiences of field engineers. The designer should use his experience to choose the ventilation value from the table. If there is any local design standards, the designer should follow them and consider them as design values.

## Reference:

- Principles of heating ventilating and air conditioning a textbook with design data based on the 2017 ASHRAE handbook fundamentals by Sauer, Harry J. Howell, Ronald Hunter Coad, William
- Fundamentals of HVAC Systems SI Edition by Robert McDowall
- مبادئ هندسة تكييف الهواء والتثليج د. خالد احمد الجودي

*Thank you very much*